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PROVISIONAL INTELLIGENCE REPORT

23

MATERIAL BALANCE ANALYSIS
OF SOVIET BLOC ECONOMIC CAPABILITIES
TO SUPPORT SPECIFIED WAR ACTIVITIES
BEGINNING IN MID-1955



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MATERIAL BALANCE ANALYSIS
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CIA/RR PR-91

(ORR Project 10.105)

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This report is designed primarily to illustrate the application of the material balance technique to the problem of estimating the economic capabilities of the Soviet Bloc to support a specified war. Its purpose is to explore and illustrate the method, the analytic techniques, and the data requirements of the material balance approach to capabilities estimation. Within the framework of the assumptions, the method, and the data available, however, the conclusions suggested by this preliminary analysis are indicative of some of the problems that would be faced by the economies of the Bloc during wartime.

Three elements impose limitations on this report -- the method itself, the data used, and the assumptions made about the war. Since the method used in this report has not hitherto been used extensively in the intelligence community, Section I is devoted to a discussion of the techniques and procedures as applied to the data available, with an evaluation of the potentialities and limitations of material balance analysis. Section II deals with the Soviet Bloc economies as they would appear in mid-1955 in absence of war. Section III is a statement of the assumptions made about the postulated war and the derivation of estimates of strategic economic resources needed to support the war. Section IV is an analysis of the impact of the war on the economies of the Soviet Bloc.

It must be borne in mind in interpreting this report that the war postulated -- a 1-year war of land, sea, and air operations employing conventional weapons and massive armies -- implies wartime demands peculiar to that type of war only. The nature of the war also influences the supply side. No damage to the economies of the Soviet Bloc is postulated. Further, accretions from conquered territory are excluded. The responses of the economies of the Bloc are thus conditioned by the nature of warfare. The analysis of stockpiles, for instance, would be quite different in a different kind of war or in a war of longer duration. Specification of air damage would significantly alter the conclusions. Changing the nature, intensity, or length of the war would require modification of the conclusions.

Several kinds of data required by the material balance technique are available only in highly tentative form at present. The data on the cold war structure of the economy are far from satisfactory or complete, and pertain primarily to the Soviet economy. In addition,

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it is necessary to know what will be the impact on an industry of transferring a part of its strategic inputs to the military sector in wartime. For instance, it is necessary to know by how much agricultural output will fall when petroleum inputs are reduced by a specific amount. Further, it is necessary to know what level of operation of an industry is compatible with the maintenance of the war effort. Agricultural production below a specific level is not consistent with supporting the war; it is necessary to know what that level is. Moreover, data on other supply and demand considerations in wartime, such as the rate of withdrawals from stockpiles and the potential wartime output of the strategic resources, are needed. As these data are developed, it will be possible to place more confidence in the results of material balance analysis.

While information from military intelligence agencies was used, especially in Section III, this report is the sole responsibility of the Office of Research and Reports.

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MATERIAL BALANCE ANALYSIS
OF SOVIET BLOC ECONOMIC CAPABILITIES
TO SUPPORT SPECIFIED WAR ACTIVITIES BEGINNING IN MID-1955*

Summary and Conclusions

The material balance technique, used in this report to test the capability of the economies of the Soviet Bloc to support large-scale warfare, has proved a useful and flexible tool of analysis. Although additional and more reliable data are needed, and despite some technical limitations, the technique is suitable for analysis of situations in which the impact on the economy is likely to be of considerable magnitude, as in the case of war. Further analysis along these lines, and examination of more varied problems, should result in more conclusive empirical results.

Preliminary results of analysis limited to a selected list of strategic resources indicate that the Soviet Bloc has the economic capability to support a 1-year war beginning in mid-1955, involving about 350 combat divisions and corresponding air, naval, and support forces.

To mount and maintain such an effort would strain to the utmost the economies of the Soviet Bloc and would entail critical shortages of many strategic resources vital to the war effort including petroleum products, steel, ammonia, manpower, and antifriction bearings. Soviet stockpiles, if used to supplement wartime supply, would cover shortages of copper, aluminum, and rubber.

In order to mitigate shortages of strategic resources within the Soviet Bloc economies, it would be necessary for the Bloc to abandon its investment program and devote most of its resources to the support of the war. In a 1-year war this support could be maintained, but should the same level of military demand extend beyond 1 year, the

* The estimates and conclusions contained in this report represent the best judgment of the responsible analyst as of 1 August 1954.

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Bloc economies would probably have serious difficulty in meeting military requirements. Should the assumption that no damage is inflicted on the home soil of the Bloc also be relaxed, then there arises the distinct possibility that the Bloc could not stand up under the economic strain imposed on it. Nonetheless, under the assumptions of this report the Bloc could support the specified military activities.

I. Method.

The method used in this report is called material balance analysis. It is so called because it makes use of a scheme whereby the supply of material is balanced against the demand for it -- that is, its consumption in the economy. By appropriate manipulations the material balance system can be made to represent the functioning of strategic sectors of the economy under several postulated conditions.

A. General.

In approaching the problem of testing the economic feasibility of supporting a war, the procedure is first to establish a bench-mark year. For this base year the consumption patterns of the selected list of strategic resources are then determined. These resources are the only resources to which the test is applicable. They are chosen partly on the assumption that singly or collectively they may represent problem sectors of the economy in wartime, and partly on the basis of availability of data. The consumption patterns for all resources are in terms of an identical set of consuming industries. The list of consuming industries exhausts the consumption of each of the resources, by definition. For the base year, which is a recent historical year, consumption is then balanced against supply, which is made up of production and imports.

After the base-year tabulation is complete, it is necessary to project these estimates to a later period in which wartime conditions are to be imposed. To do so requires an index of the change in output (and hence in inputs) for each of the consuming industries between the base year and the projected year. These indexes reflect the growth of each of these sectors in the absence of any acceleration in anticipation of war. Under the same assumptions, a supply estimate for the projected year is made. The two are matched. A brief preliminary

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analysis is made of the structure of the economy for the projected year. The analysis of the wartime situation starts from this base.

B. Data Requirements.

Material balance analysis requires six basic sets of information. They are (1) supply data, including production, import, and stockpile information; (2) demand data, including the uses to which each strategic resource is put (including exports); (3) indexes of growth for each consuming sector; (4) special estimates for the consumption structure of the projected year; (5) military requirements and appropriate data to convert these requirements into demands for resources; and (6) data on supply and demand in wartime.

For each resource it is necessary to have an estimate of production, imports, and stockpiling for both the base year and the projected year. These comprise the supply half of the material balance equation. On the demand side of the equation are placed all of the uses to which the resource is put. The consumption patterns are needed only for the base year, since the consumption patterns for the projected year are derived estimates. The methods used in making the basic production and consumption estimates are complex and varied. For the consumption patterns it is sometimes possible to derive estimates quite rigorously on the basis of known technological relationships. For other consumption patterns, only a general picture of allocations is possible. For some supply estimates a precise figure can be obtained from official statistics (electric power, for instance). In other cases a detailed analysis is required before such an estimate is possible. Imports and exports must be derived in most instances from isolated pieces of information. All the data contributing to the cold-war structure of the economy are subject to a margin of error.

The indexes for consuming industries are based upon the trend of a sample of products in each category. In any given industry a number of specific products are selected as representative of the time path of the industry as a whole. Weighting these products by their relative importance with respect to each other yields an index for the sample. It is then assumed that the entire industry moves in time as the sample does.

It is also necessary to have other information so as to correct the projection of the base-year structure of the economy to the projected year. Obviously, even if 1951 data were accurate and precise, the use of consuming industry growth indexes to move the table to

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mid-1955 would result in errors. Such errors would arise not only because the assumptions implied in the use of growth factors may not be correct but also because the structure of the economy may change over a 4-year period. Hence data to buttress the mid-1955 cold-war structure are needed.

The military information is in two parts. First, based upon assumptions as to the kind, intensity, and length of war, it is possible to derive military requirements. These data are of the form of "x" thousand tanks, "y" thousand aircraft, and so on. The other data consist of coefficients reflecting the input of strategic resources per unit output of material, such as "x" tons of steel per tank and "y" tons of aluminum per aircraft. With these two pieces of information it is possible to calculate the total quantities of all strategic resources implied by the military requirements.

Under the stress of war, supply and demand relationships change. Estimates of capacity output are needed. In addition, since it is not possible to know what the minimum nonmilitary demands in wartime would be without knowing in detail the entire range of products necessary to support the economy in war, it is necessary to have estimates of the magnitude of impact -- that is, the effect which a withdrawal of specific quantities of a strategic input would have on the output of consuming industries. With this information, estimates can be made as to whether or not the war would be likely to have an impact consistent with the continued support of the war.

All of the data used in this type of analysis must be used with caution, and care must be exercised in interpretations based upon these data. It is possible, however, to mitigate to some degree the debilitating effect of poor data by posing assumptions as to the upper and lower limits of the range and testing to determine what effect, if any, these alternatives have upon conclusions and interpretations. All the data are in plain view. They are not subsumed in aggregates or concealed by complicated procedures in such a way as to preclude testing the effect of a change in data.*

C. Base-Year Chart.

The base-year chart embodies the supply and demand data for the base year. In the present study, 1951 was selected as the base year.

* It is true, of course, that most of the data -- estimates of production, consumption allocations, stockpiles, and so forth -- are themselves obtained only after analysis.

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The tabulation appears as Table 1.* In the table each row represents a strategic resource. These are (1) coal, (2) petroleum distillates, (3) petroleum residuals, (4) electric power, (5) steel, (6) copper, (7) aluminum, (8) lead, (9) zinc, (10) ammonia, (11) toluene, (12) rubber, (13) antifriction bearings, and (14) manpower. The table shows in detail the uses of these items by 30 consuming industries for the USSR. The consuming industries are listed in the columns of the table. Another column gives total demand, the sum of all the entries to its left in any given row.

In addition, there are several columns in the base-year table which show the supply picture for that year. In the base year, supply and demand are equal by definition and hence there is no surplus or deficit. Another column indicates for each resource the accumulated stockpile. Since the detail is only for the USSR, it is necessary to show the production of the European Satellites and Communist China and the Soviet Bloc stockpile in additional columns.

Thus the base-year table is simply a collection of data. These data provide the basis for further manipulation and become the subject of special estimates and assumptions for analysis of economic capabilities.

D. Consuming Industry Growth Rates.

The projected year in the present study is the year ending in mid-1955. It is therefore necessary to have for each consuming industry an index for mid-1955 over 1951. These indexes depict the growth of these sectors of the economy in the absence of any build-up. They are derived from production estimates of products within the various sectors. The indexes for this study are given in Table 2.**

The index for any given sector is multiplied by all the resources which it consumes in the base year, thus providing an estimate of the consumption of that resource in the projected year. The application of these growth factors implies that the input of all strategic resources is related strictly to the output of the industry, this relationship being such that for every unit of output of the consuming industry a specific and constant quantity of the resource is necessary.

* P. 13, below.

** P. 16, below.

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Such assumptions leave much to be desired realistically. In fact, input coefficients change over time, and the input of some resources is related not to the output of the consuming industry but to some other characteristic of the industry.

E. Special Estimates.

For several sectors there is no meaning at all attached to the consuming industry index. These sectors are exports and inventory change. Where there is no specific information it is initially assumed that exports in mid-1955 are at the same level as in 1951. Inventory change is assumed to be related to Soviet production so that the same ratio exists between the two in mid-1955 as in 1951.

For particular entries it also is necessary to make special estimates. Agricultural employment and military manpower are two examples where the growth factors do not fit. Special computations were made for both agricultural employment and military manpower.

In a number of instances such as those cited above (copper uses and petroleum used in agriculture), special estimates were made and embodied in the projected-year chart.

As an example, suppose that in 1951 there existed a shortage of copper -- that is, not only that consuming industries were compelled to make less of that part of their output using copper but also that the copper-using output that they did make was lean on copper use, substitutes were used, inferior products were made, and the input coefficient of copper was lower than it would have been if copper had not been short. Suppose, however, that in mid-1955 this shortage was overcome, so that those items requiring copper had as much copper as was technically and economically desirable, substitutes were eliminated, and inferior products were not made. The input coefficient for copper would then be larger than in 1951, and the use of a growth factor with the 1951 allocation to copper-using industries would result in a mid-1955 allocation which was too low.

In another instance, suppose that the use of petroleum distillates in agriculture is not a function of agricultural output but rather of the stock of capital equipment -- tractors in particular -- in that sector, and that the tractor park is growing faster than agricultural output is growing. Here again, the use of agricultural growth with the 1951 allocation would result in too low an allocation for mid-1955.

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These two instances are actual occurrences. Still other instances might be cited. It is obvious that it is not possible to apply the growth factors blindly and expect satisfactory results. Each consuming industry and each strategic resource must be considered separately, and adjustments must be made whenever there is evidence that the assumption does not hold.

F. Projected-Year Chart.

The consumption and supply data for the projected-year chart for mid-1955 are shown in Table 3.* Table 3 was derived in the manner described above, by applying growth factors to the allocations for all consuming industries or, in some cases, where this procedure was inapplicable, by making special estimates. These methods permit filling in all of the allocations across the table to the total demand column, which is simply the sum of all the consumption estimates in any given row. It is then necessary to enter the estimate of mid-1955 production, imports, and stockpiles in the USSR, as well as production for the European Satellites and Communist China. The difference between mid-1955 supply and demand is entered as a deficit or surplus in appropriate columns. This projected-year chart is then the preliminary estimate of mid-1955 cold-war consumption structure for these resources, without any allowance for changes in the structure of the economy and before taking into consideration possible errors up to this point.

G. Mid-1955 Analysis.

The analysis of material balances for mid-1955 is only a preliminary analytical stage and is designed primarily to indicate any chronic deficiencies in the economy and to correct any inadequacies in the data and the analysis. Where deficiencies occur, it is necessary to indicate how they will be met; where surpluses occur, it is necessary to indicate where these resources will be absorbed. Such analysis is not extensive and merely sets the stage for the utilization of a new set of data, the combat attrition information, and for a more refined analysis of the impact of wartime demands on these resources.

A surplus or deficit in the projected-year chart (mid-1955) can be explained by one or more of the following factors. (1) Resource production estimates in 1951 or mid-1955 may be too high or too low. (2) Consuming industry growth rates may be too low or too high.

* P. 19, below.

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(3) Consuming industries with high or low growth rates are not allocated so much as they should be, and consumers with low or high growth rates may be allocated more than they should be. (4) Defense, stockpiling, and imports and exports may be too low or too high. (5) The resources studied are, or are not, being used in quantity in activities showing little or no growth. (6) Certain consuming industries are not counted or are inadequately counted, or some users are double counted. (7) The 1951 allocation from which input coefficients are derived may be too low or too high for projection to mid-1955. (8) Finally, the resources studied are, or are not, in short supply.

By examining the data in the tables, it is possible to relate a surplus or a deficit to the relative rates of growth. For instance, a deficit can be traced to the fact that output of the deficit product is growing at a rate slower than the rates of output of its principal consumers. Conversely, output of a product of which there is a surplus may be growing faster than the output of its principal consumers. The observation of this relationship, of course, does not provide an understanding of the phenomena, which can come only with an examination of the relevant data and the substance of what lies behind the estimates.

H. Wartime Demand.

To determine the requirements of war necessitates defining at some length just what war and what kind of war is to be analysed. This includes a statement of force levels, tables of organization and equipment, and time period, as well as strategy and kind and force of opposition. From such assumptions it is possible to derive the requirements of the war for military end items, manpower, and auxiliary equipment. From these military requirements and a knowledge of the input of strategic resources per unit output for all the different kinds of military materiel it is possible to derive the economic resources required to meet the military requirements. These new economic demands, occasioned by the war, are then substituted for the demands of defense industries under cold-war assumptions.

It is at this point that the analysis begins. It is necessary to consider all the possible actions which might be taken, both on the supply and the demand side, in order to strike a balance in the economy and still meet the demands of war. The demands for these resources in wartime are not the actual demands which will in fact be imposed. Rather, they are computed on the basis that (1) all units are fully manned and equipped, and (2) that attrition in the field is met by

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concurrent production at home. Suppose, for instance, a tank division has, during the cold war, a complement of only 5,000 men and 100 tanks. Upon mobilization it is necessary to fill out the table of organization and equipment, which calls for 11,500 men and 250 tanks. The men must be called up; the tanks must be taken out of storage. This particular division is one of the combat units and hence is subject to attrition for the period mid-1955 to mid-1956. The attrition rate, based upon historical experience, is 10 percent per month, or 288 tanks per year.

Based on the design and construction of the particular kinds of tanks involved, it is possible to determine the input of each strategic resource. Each tank requires specific quantities of steel, copper, aluminum, and so forth; and electric power, coal, and other inputs are consumed in its manufacture.

It can be seen that such data are not actual demands, but rather are fabricated on the basis of fully equipped military units and the presumption that combat attrition is reflected at once by demands upon the economy. In fact, the demands upon the economy are much less certain. Upon mobilization it is possible that some units would go to the field not fully equipped. In addition, attrition is an uncertain measurement. Even if attrition were as stated, attrition actually would not be met at once. The park or stock of equipment would be depleted, orders would be placed, and after a lag there would result a demand upon the economy. Furthermore, even if the demands are levied, there is no certainty that there are sufficient fabricating facilities to make the number of tanks demanded. In this case, the demand for the strategic resources would be lower because the number of tanks ordered was not produced.

Thus the demands as calculated by the above procedure represent an upper limit for the force levels involved and a fictitious computation as far as the actual demands are concerned. Nonetheless, they do provide a measure of the magnitude of resource commitments which are necessary to maintain the specified war effort.

I. Analysis of Wartime Demand.

Analysis is in general not a procedure which can be outlined precisely and detailed step by step. Section IV, below, contains the analysis of this particular problem. The purpose of the analytical stage is to determine whether or not there are courses of action open to the Soviet Bloc whereby the demands of the war can be met

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while simultaneously maintaining the rest of the economy above collapse level.

The general condition, upon the imposition of wartime demands, is that the Soviet Bloc will appear short of every item in the strategic list except where the entire accumulated stockpile is used to offset the demand. Thus the primary analytical problem is to determine whether or not the Bloc can arrange its economic affairs in such a manner as to avoid the shortage or eliminate its crippling effects. A number of courses of action are open to the Bloc and must be analyzed separately for each strategic resource. Some of these responses act on the demand side; others on the supply side. On the supply side it may be possible for the Bloc (1) to accelerate production of the strategic sectors more rapidly from mid-1955 to mid-1956 than would be estimated under nonwar conditions, (2) to use strategic stockpiles of these strategic resources, (3) to use resources from conquered territory, (4) to salvage plant and equipment for their strategic resources, and (5) to shorten and eliminate the pipeline of strategic resources to all sectors. On the demand side it may be possible for the Bloc (1) to eliminate exports, (2) to cut back production in sectors using strategic resources for which the output is nonstrategic, (3) to eliminate some nonstrategic inputs into lines of production which use strategic inputs, and (4) to substitute nonstrategic inputs or less strategic inputs, wherever possible, for strategic resources.

An essential ingredient of the analytic stage is the attempt to determine those sectors whose activities must be curtailed in order to meet the war demand. A withdrawal of inputs from a consuming sector and reallocation to the military will adversely affect the output of the consuming industry. The extent of the impact of specific withdrawals and the level of output which can be maintained by the consuming industry with the inputs left to it are central to material balance analysis.

As a necessary part of the analytical stage, it is also pertinent to call into question all the data on which the preceding analysis rests. In particular, the consumption patterns and the wartime demands must be scrutinized closely. The use patterns are based upon an updating of 1951 data. The wartime demands are a calculation based upon meeting attrition. It may be that fabricating or manufacturing capacity is so limited that even if the resources were available it would not be possible to fabricate enough to use the indicated amount.

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This limitation would in effect reduce the wartime demand for the resource. It is also possible that the supply estimates are lower than they should be. Some analytical manipulation of both supply and demand estimates is necessary to indicate the extent to which errors in such estimates affect the results of the research.

As can be seen in Section IV, below, it was necessary to use quite unsophisticated techniques in the analysis of the wartime situation. As a first approximation industrial demand in the prewar period was estimated by various techniques. This provides a picture of the initial position, one in which the cold-war structure has remained unchanged. It is recognized that this situation must and will change under the impact of the war demands. Not only would reallocations be made, but also the actual technological structure would change as the war influenced relative values and substitutes were introduced.

J. Limitations and Potentialities of the Method.

It is worth noting that, in an abstract sense, the test is one which in fact tests the internal consistency of the several sets of data. Only insofar as these data represent the actual situation in the USSR can the test be called a real test of capabilities. All quantitative testing techniques suffer from this limitation. In the present test two considerations, however, make this factor of some importance. First, it is not certain, in dealing with the USSR, whether or not a datum is accurate, much less whether or not a whole complex of data represents the factual situation. It is seldom that complete confidence can be placed in Soviet data. Second, the data used in the material balance technique are interrelated. The projected-year production estimates of the resources to be tested are also a part of the data of the consuming industry growth indexes. Because data are lacking, some of the allocations are made a function of the output of the producing sector, not the consuming sector.

The data pose a serious limitational factor for material balance analysis. It is one which can be overcome only by long-term research. At present, there is some reliance upon analogous US data and quite limited knowledge and understanding of Soviet consumption structure. As more research is performed, the estimates will become more reliable. The lack of data is especially serious in the analysis of the impact of war demands. Information on what sectors will be cut back and what the effect of these cutbacks would be is of crucial importance, but frequently only conjectural data are available.

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There are certain technical limitations to this type of analysis, limitations inherent in what is, in effect, an attempt to analyze a general equilibrium problem with partial equilibrium techniques. The problem of the impact of wartime demands upon an economy is a general equilibrium problem, but material balance methods are partial in scope. An increase in the demand for aluminum results in an increase in all the inputs into the aluminum industry. The industries which supply the aluminum industry find their outputs have risen, and hence inputs into these industries have also increased. These supplying industries likewise have increased outputs and hence increased inputs. In this fashion the indirect effects of a change in demand can be traced through the economy and determined with some precision. The material balance technique, because it does not include all producing industries and because there is no differentiation between interindustrial and final demand (external) sectors, cannot take account of these interrelated transactions which in fact take place. In the material balance approach they must be approximated by making special assumptions about what happens to various consuming industries upon the imposition of new demands.

A significant characteristic of the material balance method is that no generalizations are possible beyond the specific list of items which are tested. When, as is usually the case, the list of resources is quite limited and does not contain many items which are of great importance to the economy, the usefulness of the technique is somewhat impaired. Since many of the strategic resources cannot be measured adequately when disaggregated to the level where this technique is applicable, it is possible that the technique has a definite upper limit on the number of items which can be included in a material balance analysis.

The material balance method may still be extended in coverage, however, to a more exhaustive list of strategic resources, and the number of consuming industries may be proliferated and refined. It is cumulative research, such that additional or better data may be inserted to improve the data as they are required. The method is a highly practical and pragmatic method for testing economic feasibility within well-defined limits and is arranged in such a manner that the data are open to scrutiny and examination with little opportunity for concealed assumptions. There is considerable potential value in the material balance method as it becomes possible to examine a more extensive list of products in this way and as the quality of the data improves.

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